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PRELIMINARY STANDARDIZED CATCH RATES IN NUMBER OF FISH BY AGE FOR THE SOUTH ATLANTIC SWORDFISH (*XIPHIAS GLADIUS*) OF THE SPANISH LONGLINE FLEET, FOR THE PERIOD 1989-2011 ASSUMING A TENTATIVE GROWTH MODEL

Jaime Mejuto[1], Ana Ramos-Cartelle[1] and Blanca García-Cortés[1]

SUMMARY

Trials of standardized catch rates in number of fish by age were done using log-normal General Linear Modeling (GLM) from trips carried out by the Spanish surface longline fleet in the South Atlantic swordfish stock. Indices were developed for a 23 years period (1989-2011) for ages ranging from 1 to 5+, assuming the Gompertz's sex-combined growth model of the North Atlantic swordfish as a proxy for ageing the size data per trip. The criteria used to define areas, time periods and models were similar to those used to develop the biomass index, including information such as gear style, a target variable and bait type. The models explained between 29% and 66% of the CPUE variability. Despite the growth assumptions used, the trials show significant diagnoses and quite stable trend over time of the standardized CPUEs by age obtained.

RÉSUMÉ

Des essais de taux de capture standardisés en nombre de poissons par âge ont été réalisés à l'aide de la modélisation linéaire généralisée log-normale (GLM) obtenus des sorties réalisées par la flottille palangrière de surface espagnole pêchant l'espadon de l'Atlantique Sud. Des indices ont été élaborés pour une période de 23 ans (1989-2011) pour des âges allant de 1 à 5+, en postulant un modèle de croissance de sexe combiné de Gompertz pour l'espadon de l'Atlantique Nord comme indice approchant pour déterminer l'âge d'après les données de taille par sortie. Les critères utilisés pour définir les zones, les périodes temporelles et les modèles étaient similaires à ceux utilisés pour élaborer l'indice de la biomasse, y compris l'information comme le style de l'engin, une variable cible et le type d'appât. Les modèles expliquaient entre 29% et 66% de la variabilité de la CPUE. En dépit des postulats de croissance utilisés, les essais ont fait apparaître d'importants diagnostics et une tendance assez stable dans le temps des CPUE standardisées par âge qui avaient été obtenues.

RESUMEN

Se ensayaron tasas de captura normalizadas en número de peces por edad mediante Modelos Lineales Generalizados (GLM) del tipo log-normal a partir de mareas individualizadas realizadas por la flota española de palangre de superficie de pez espada en el stock del Atlántico sur. Los índices fueron desarrollados para un periodo de 23 años (1989-2011) para las edades entre 1 y 5+ años asumiendo como una aproximación un modelo de crecimiento tipo Gompertz (sexo-combinado) para convertir los muestreos de talla por marea en edades. El criterio usado para definir las áreas, los periodos temporales y los modelos fue similar al aplicado para obtener un índice en biomasa, incluyendo también el estilo de arte de pesca, una variable de direccionamiento y el tipo de cebo. Los modelos significativos explicaron entre el 29% y el 66% de la variabilidad de la CPUE. Pese a las supuestos de crecimiento utilizados, los ensayos mostraron diagnósticos significativos y una tendencia bastantes estable de las CPUE por edad obtenidas para ese periodo.

KEYWORDS

Swordfish, Age specific CPUE, GLM, Longline

[1] Instituto Español de Oceanografía. P.O. Box 130, 15080 A Coruña. Spain; tunidos.corunha@co.ieo.es

1. Introduction

Recent studies have pointed out that the research effort on the South Atlantic swordfish stock has generally been scarcer and poorer than for the northern stock. The historical differences between the driven research for decades are obvious, reaching the conclusion that *'It could be argued that the greater investment in research has had tangible impact on the quality of the assessment advice'* (Neilson *et al*. 2013). Several historical factors have affected both applied research efforts on each of these stocks of Atlantic swordfish and also within each stock unit.

The history of the commercial North and South Atlantic fisheries is different, which has conditioned the means provided by the respective countries during each historical period, not necessarily proportional to the importance of each fishery. The most important commercial swordfish fisheries in the Atlantic have carried out their activity for several decades since the nineteenth century in the NW Atlantic regions, performing pioneering research efforts during those periods. The Canadian swordfish harpoon fishery began commercially in the late 1880s using sailing vessels. Historical references on studies of swordfish in the Atlantic NW have been documented at least since the nineteenth century (Goode 1883). Research was very stimulated from the sixties-seventies of the twentieth century, first on harpoon fisheries that were initially dominant in the NW Atlantic and later on longline fisheries that became more prevalent in levels of capture and their geographic and temporal distribution since the 1960s. Some descriptions about growth of the North Atlantic swordfish were suggested from at least 1922 onwards, but most studies using hard parts were developed from the middle of the twentieth century and especially during later decades (Palko *et al.* 1981, Berkeley and Houde 1983) later updated by several authors (see Neilson *et al.* 2013 for details). The development and expansion of fisheries in the NE Atlantic occurred mostly during the eighties of the twenty century. Investigations began after the end of the seventies leveraging this development and geographical expansion of the fishery in the NE Atlantic areas.

The development of the swordfish commercial fishery in the South Atlantic stock is relatively more recent. The ICCAT historical catch records date from at least 1950, but the highest fishing intensity and geographical expansion of targeted oceanic fisheries has occurred since the mid-eighties and especially during the nineties of the last century. The means provided for research has been uneven compared to those historically used for NW regions. Tangible examples of some deficiencies in research could point out, among others, the lack of conventional tagging programs with enough historical projection -in the NW Atlantic they were initiated in mid of twentieth century- and the lack of studies on some basic biological parameters such as growth and comprehensive studies on stock structure, etc. The high uncertainty caused by these gaps in research has led to more precautionary recommendations on allowable catch levels. One additional element to be considered as limiting is the historical lack of ICCAT research programs on swordfish that contribute to encourage studies on this species, unlike with many other ICCAT species such as albacore, skipjack, billfish, bluefin tuna, bigeye tuna, etc. Research efforts on swordfish frequently have had little means in the vast majority of countries. Yet despite this, the diagnosis of SCRS about the quality of the basic fishery data available was regularly more favorable than for many other ICCAT species.

This paper, while being aware of these limitations of existing research, is an exercise to tentatively explore indicators of "abundance" in numbers of fish by age for the South Atlantic swordfish stock. However, due to the lack of a growth model for this stock, two concatenate premises have been taken: (1) No substantial differences would be expected between growth rates of the North and South swordfish management stocks because it is a cosmopolitan species of wide geographical distribution-mixing in the Atlantic. (2) The growth model for North Atlantic swordfish for combined sexes obtained from tagging-recapture could be assumed as a tentative approximation also applicable to the South Atlantic stock.

2. Material and methods

The trip-size data used were obtained during a period of 23 years (1989-2011) from the Spanish longline fleet fishing on the South Atlantic swordfish stock. Data voluntarily provided for scientific purposes were recorded. The methods and specifications used in this paper aimed to be consistent as far as possible with previous analyses in biomass of the South Atlantic stock (Ramos-Cartelle *et al.* in press) and the methodology used for the North Atlantic age specific (Mejuto *et al.* in press). A brief summary is presented in this paper. Two important events have been considered: a) The introduction of monofilament gear style – the American style- and b) the change of the targeting criteria of the fleet related to the previous decades reported. The North Atlantic sex-combined Gompertz's type equation (Anon. 1989) was assumed as a proxy for the South Atlantic stock to obtain number of fish by age (ages 1 to 5+) from catch at size data per trip. The conversion from size into age was carried out using software applying the "slicing" technique (Restrepo *pers. comm.*) updated on visual basic. Trips with size-sampling coverage below 85% of their catch in number were omitted from the analysis as also implemented for the base case run of the North Atlantic stock. Any substitution procedure of size information among trips was implemented in this analysis. The target variable “ratio” was defined for each trip as the percentage in weight of swordfish landed in relation to the swordfish and blue shark combined (Mejuto and De la Serna 2000, Ortiz 2010, Ortiz *et al.* 2010). The target variable was categorized into ten categories of 10% intervals. The temporal definition corresponding to "quarters" was: Q1 = January, February, March; Q2 = April, May, June; Q3 = July, August, September; Q4 = October, November and December. Two levels of gear styles were defined: 1= traditional multifilament mainline, 3= new monofilament. Three levels of bait types were considered: 1= mackerel, 6= squid and 9= other types or combinations (García-Cortés *et al.* in press, Mejuto *et al.* in press). The hypothetical boundary line between North and South Atlantic stocks was kept at 5ºN latitude as assumed by the ICCAT. The spatial definition considered 5 areas as used in previous analyses in number and biomass age combined (Ramos-Cartelle *et al.* in press). The standardized log-normal CPUE analyses were performed using GLM procedures (*SAS 9.2 ver.*). The model was defined as: LOG (CPUE) = u + Y + Q + A + R + G + B + A*Q + e, where: u = overall mean, Y= effect year, Q= effect time (quarters), A= effect area, R= effect ‘ratio’, G= effect gear style, B= bait type, e= logarithm of the normally distributed error term.

3. Results and discussion

A total number of 4,328 trips were available from the period 1989-2011. **Table 1** is a summary of the ANOVA results obtained for age-specific analysis. The number of observations finally used, R-square, mean square error (root) and F-statistics for each age-class are provided. The model by age explained between 29%-66% of the CPUE variability. The scarcer availability of the ages 1 fish compared to other ages could explain the lower fit obtained for age 1. **Table 2** shows the estimated parameters obtained from the CPUE analyses in number of fish by age. The area and ratio are the most important factors for explaining the variability of the age 1 CPUE. The variable year and quarter seem to also be relatively important factors for age 1 suggesting that the inter-annual variability or the quarters play a moderate role. The ratio is the most important factor for explaining the CPUE variability of the other ages considered. The type III SS suggest a different ranking of the other factors for the different ages as would be expected in a species segregated by size-ages and targeted by fleets with extensive fishing experience. The bait factor was not significant for most ages or explained a negligible part of the CPUE variability. **Figures 1** and **2** represent the normal fit, the frequency distribution of the standardized residuals and the normal probability qq-plot diagnosis of the GLM run for standardized CPUE in number of swordfish by age. **Figure 3** presents the variability box-plot of the standardized residuals by year for each age. **Table 3** provides information on estimated parameters, their standard error, CVs%, standardized CPUE by age and upper and lower 95% confidence limits obtained. The mean standardized CPUE by age and their confidence intervals 95% are plotted (**Figure 4)**. Additional information about the geographical coverage of this fishery can be found in Ramos-Cartelle *et al.* (in press.).

The results should be considered preliminary and conditional on assumed premises. In this type of analysis by age, it is especially important the likelihood of the growth model applied and the method used to convert lengths into ages. Both conditions are important in species with differential growth by sex and area-time segregation, as the process of “ageing” can produce inadequate catch at age matrices in relation to the true demographic structure of the population. It seems biologically plausible to expect that the growth rates of North and South Atlantic swordfish were not very different. Most studies conducted to date for the swordfish of the Atlantic and even from other oceans have not generally shown broad differences in growth estimations among authors (Esteves *et al.* 1995, Neilson *et al.* 2013). This similarity in the basic biological parameters is usually observed in the case of cosmopolitan highly migratory pelagic fish species evolutionary connected, with expected genetic population admixture beyond the stock management boundaries assumed and when samples used in the respective studies are equivalent and the methods of reading and interpretation of the hard parts -or tagging and recapture data- are standardized among authors. Despite these limitations, the trials show significant diagnoses and a relatively stable trend over time of the standardized CPUEs by age obtained for the analyzed period.

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Table 1. Summary of ANOVA base case analysis in number of fish by age in the South Atlantic stock: Number of observations, R- square, mean square error (root) and F-statistics for each age considered.

YEARS	AGE	#OBSERV.	R-Square	RMSE	F-STAT.
1989-2011	1	3341	0.294649	1.002720	25.91
1989-2011	2	4259	0.476567	0.641120	72.24
1989-2011	3	4318	0.613603	0.487930	127.76
1989-2011	4	4307	0.659962	0.498027	155.74
1989-2011	5+	4292	0.658340	0.538224	154.11

Table 2. Summary of ANOVA by factor for CPUE analysis, in number of swordfish by age for the South Atlantic stock for the 1989-2011 period.

YEARS	AGE	FACTOR	DF	Type III SS	M-Square	F-Value	Pr > F
1989-2011	1	yr	22	142.9713787	6.4986990	6.46	<.0001
1989-2011	1	qtr	3	141.8248439	47.2749480	47.02	<.0001
1989-2011	1	area	4	283.1073250	70.7768312	70.39	<.0001
1989-2011	1	gear	1	71.9852640	71.9852640	71.6	<.0001
1989-2011	1	bait	2	1.2547874	0.6273937	0.62	0.5359
1983-2011	1	ratio	9	207.1870945	23.0207883	22.9	<.0001
1983-2011	1	qtr*area	12	44.9501667	3.7458472	3.73	<.0001
1983-2011	2	yr	22	138.7306980	6.3059408	15.34	<.0001
1983-2011	2	qtr	3	223.4931530	74.4977177	181.24	<.0001
1983-2011	2	area	4	91.2315490	22.8078873	55.49	<.0001
1983-2011	2	gear	1	108.9153029	108.9153029	264.98	<.0001
1983-2011	2	bait	2	3.4428503	1.7214252	4.19	0.0152
1983-2011	2	ratio	9	521.5388142	57.9487571	140.98	<.0001
1983-2011	2	qtr*area	12	29.9449120	2.4954093	6.07	<.0001
1983-2011	3	yr	22	77.6793731	3.5308806	14.83	<.0001
1983-2011	3	qtr	3	21.1864861	7.0621620	29.66	<.0001
1983-2011	3	area	4	19.3574416	4.8393604	20.33	<.0001
1983-2011	3	gear	1	78.6619300	78.6619300	330.41	<.0001
1983-2011	3	bait	2	0.6758728	0.3379364	1.42	0.242
1983-2011	3	ratio	9	715.0941145	79.4549016	333.74	<.0001
1983-2011	3	qtr*area	12	25.7160887	2.1430074	9	<.0001
1983-2011	4	yr	22	49.5243779	2.2511081	9.08	<.0001
1983-2011	4	qtr	3	156.6961221	52.2320407	210.59	<.0001
1983-2011	4	area	4	22.4469325	5.6117331	22.63	<.0001
1983-2011	4	gear	1	54.2796583	54.2796583	218.84	<.0001
1983-2011	4	bait	2	1.1145584	0.5572792	2.25	0.1059
1983-2011	4	ratio	9	774.6711795	86.0745755	347.03	<.0001
1983-2011	4	qtr*area	12	57.8241918	4.8186827	19.43	<.0001
1983-2011	5+	yr	22	67.5787159	3.0717598	10.60	<.0001
1983-2011	5+	qtr	3	167.0027346	55.6675782	192.17	<.0001
1983-2011	5+	area	4	232.3430452	58.0857613	200.51	<.0001
1983-2011	5+	gear	1	41.4208387	41.4208387	142.99	<.0001
1983-2011	5+	bait	2	2.8323833	1.4161917	4.89	0.0076
1983-2011	5+	ratio	9	867.0526878	96.3391875	332.57	<.0001
1983-2011	5+	qtr*area	12	41.2670281	3.438919	11.87	<.0001

Table 3. - Estimated parameters (LSMEAN), standard error (STDERR), CV%, relative CPUE in number by age (CPUEn) and upper and lower 95% confidence limits (UCPUEn, LCPUEn) for the analysis of the South Atlantic stock for the years 1989-2011.

Age 1

YR	LSMEAN	STDERR	CV%	UCPUEn	CPUEn	LCPUEn
1989	-0.6297	0.2252	35.7678	0.8497	0.5464	0.3514
1990	-1.0546	0.2125	20.1487	0.5404	0.3563	0.2349
1991	-1.3777	0.1310	9.5097	0.3288	0.2543	0.1968
1992	-1.5267	0.1209	7.9196	0.2774	0.2188	0.1727
1993	-0.8688	0.0921	10.6025	0.5046	0.4213	0.3517
1994	-0.8597	0.0924	10.7490	0.5095	0.4251	0.3547
1995	-0.8306	0.0914	11.0005	0.5234	0.4376	0.3659
1996	-0.7204	0.0881	12.2310	0.5805	0.4885	0.4110
1997	-0.6559	0.0779	11.8690	0.6064	0.5206	0.4469
1998	-0.9417	0.0832	8.8295	0.4606	0.3913	0.3325
1999	-0.9362	0.0851	9.0853	0.4649	0.3935	0.3331
2000	-0.3919	0.0949	24.2052	0.8175	0.6788	0.5637
2001	-0.6287	0.0847	13.4750	0.6319	0.5352	0.4533
2002	-0.6299	0.0902	14.3193	0.6383	0.5349	0.4482
2003	-0.8231	0.0894	10.8561	0.5252	0.4408	0.3700
2004	-0.4714	0.1113	23.6174	0.7812	0.6280	0.5049
2005	-0.6838	0.1271	18.5881	0.6528	0.5088	0.3966
2006	-0.6055	0.1155	19.0676	0.6890	0.5494	0.4382
2007	-0.4293	0.1592	37.0891	0.9007	0.6593	0.4826
2008	-0.9643	0.1281	13.2860	0.4941	0.3844	0.2991
2009	-0.4067	0.1520	37.3663	0.9073	0.6736	0.5001
2010	-1.0208	0.1467	14.3728	0.4856	0.3642	0.2732
2011	-0.3526	0.1389	39.3930	0.9317	0.7097	0.5406

Age 2

YR	LSMEAN	STDERR	CV%	UCPUEn	CPUEn	LCPUEn
1989	0.3826	0.1390	36.3280	1.9438	1.4803	1.1273
1990	-0.2799	0.1272	45.4344	0.9777	0.7620	0.5939
1991	-0.0980	0.0757	77.1781	1.0546	0.9092	0.7839
1992	-0.2122	0.0644	30.3549	0.9196	0.8105	0.7144
1993	-0.3818	0.0518	13.5673	0.7566	0.6836	0.6176
1994	0.1202	0.0520	43.2244	1.2503	1.1293	1.0199
1995	0.1737	0.0516	29.7288	1.3181	1.1913	1.0766
1996	0.1627	0.0506	31.1201	1.3010	1.1782	1.0669
1997	0.2377	0.0440	18.5134	1.3840	1.2696	1.1647
1998	0.3492	0.0458	13.1035	1.5527	1.4195	1.2977
1999	0.1331	0.0481	36.1635	1.2568	1.1437	1.0407
2000	0.2573	0.0525	20.4159	1.4357	1.2952	1.1685
2001	0.4315	0.0471	10.9157	1.6903	1.5413	1.4053
2002	0.1520	0.0490	32.2589	1.2832	1.1656	1.0588
2003	0.2737	0.0516	18.8564	1.4567	1.3166	1.1899
2004	0.1345	0.0579	43.0314	1.2834	1.1458	1.0230
2005	0.4053	0.0669	16.5088	1.7138	1.5031	1.3184
2006	0.1102	0.0671	60.8636	1.2763	1.1191	0.9812
2007	0.5074	0.0832	16.3953	1.9619	1.6667	1.4160
2008	0.3349	0.0705	21.0404	1.6088	1.4013	1.2205
2009	0.2101	0.0681	32.4353	1.4133	1.2366	1.0820
2010	0.4505	0.0750	16.6589	1.8228	1.5735	1.3582
2011	0.1718	0.0722	42.0189	1.3714	1.1905	1.0335

Table 3 (cont.)

Age 3

YR	LSMEAN	STDERR	CV%	UCPUEn	CPUEn	LCPUEn
1989	0.4903	0.1057	21.5510	2.0197	1.6419	1.3348
1990	0.5866	0.0968	16.4962	2.1836	1.8063	1.4943
1991	0.5669	0.0572	10.0972	1.9753	1.7657	1.5783
1992	0.3250	0.0488	15.0272	1.5249	1.3857	1.2592
1993	0.2118	0.0390	18.3991	1.3349	1.2368	1.1458
1994	0.4375	0.0394	8.9993	1.6743	1.5500	1.4349
1995	0.6971	0.0391	5.6135	2.1696	2.0094	1.8611
1996	0.5335	0.0383	7.1699	1.8389	1.7061	1.5829
1997	0.4330	0.0333	7.6852	1.6468	1.5428	1.4454
1998	0.6463	0.0347	5.3735	2.0442	1.9097	1.7840
1999	0.6550	0.0366	5.5814	2.0696	1.9265	1.7933
2000	0.7979	0.0400	5.0145	2.4039	2.2226	2.0550
2001	0.6755	0.0355	5.2571	2.1079	1.9662	1.8340
2002	0.4800	0.0375	7.8014	1.7405	1.6173	1.5028
2003	0.5834	0.0383	6.5718	1.9334	1.7934	1.6636
2004	0.7464	0.0434	5.8188	2.2989	2.1114	1.9391
2005	0.7553	0.0509	6.7361	2.3545	2.1311	1.9288
2006	0.8100	0.0509	6.2887	2.4872	2.2509	2.0370
2007	0.5405	0.0633	11.7026	1.9473	1.7203	1.5197
2008	0.7345	0.0536	7.2961	2.3186	2.0874	1.8793
2009	0.8052	0.0498	6.1788	2.4693	2.2399	2.0318
2010	0.6773	0.0568	8.3787	2.2037	1.9718	1.7642
2011	0.7051	0.0536	7.5959	2.2514	2.0270	1.8250

Age 4

YR	LSMEAN	STDERR	CV%	UCPUEn	CPUEn	LCPUEn
1989	0.2710	0.1079	39.8022	1.6296	1.3190	1.0676
1990	0.5197	0.0988	19.0124	2.0507	1.6897	1.3922
1991	0.3863	0.0585	15.1371	1.6530	1.4740	1.3144
1992	0.2439	0.0499	20.4567	1.4092	1.2779	1.1588
1993	0.1278	0.0399	31.2050	1.2297	1.1372	1.0517
1994	0.1997	0.0403	20.1522	1.3224	1.2221	1.1294
1995	0.3690	0.0400	10.8416	1.5656	1.4475	1.3383
1996	0.2674	0.0392	14.6554	1.4120	1.3076	1.2109
1997	0.0673	0.0341	50.6320	1.1441	1.0702	1.0011
1998	0.1106	0.0355	32.0918	1.1982	1.1177	1.0426
1999	0.2717	0.0373	13.7426	1.4128	1.3131	1.2204
2000	0.4052	0.0410	10.1076	1.6264	1.5009	1.3851
2001	0.2746	0.0364	13.2542	1.4143	1.3169	1.2262
2002	0.1956	0.0383	19.6052	1.3119	1.2169	1.1288
2003	0.0759	0.0392	51.6405	1.1659	1.0797	0.9998
2004	0.2555	0.0445	17.4024	1.4101	1.2924	1.1846
2005	0.2683	0.0522	19.4595	1.4505	1.3095	1.1821
2006	0.4548	0.0520	11.4387	1.7473	1.5779	1.4250
2007	0.1972	0.0646	32.7400	1.3852	1.2205	1.0754
2008	0.0984	0.0547	55.6086	1.2302	1.1051	0.9927
2009	0.2784	0.0508	18.2458	1.4612	1.3227	1.1974
2010	0.1697	0.0579	34.1366	1.3297	1.1870	1.0596
2011	0.1128	0.0547	48.4754	1.2480	1.1211	1.0071

Table 3 (cont.) Age 5+

YR	LSMEAN	STDERR	CV%	UCPUEn	CPUEn	LCPUEn
1989	-0.1606	0.1166	72.5903	1.0776	0.8574	0.6823
1990	0.6089	0.1068	17.5327	2.2793	1.8490	1.4999
1991	0.4853	0.0632	13.0200	1.8426	1.6280	1.4383
1992	0.4276	0.0539	12.6114	1.7069	1.5357	1.3817
1993	0.4146	0.0430	10.3797	1.6485	1.5151	1.3926
1994	0.4070	0.0435	10.6784	1.6374	1.5037	1.3809
1995	0.4116	0.0432	10.5021	1.6443	1.5107	1.3880
1996	0.2763	0.0423	15.2919	1.4333	1.3194	1.2146
1997	0.2735	0.0368	13.4494	1.4138	1.3154	1.2239
1998	0.1541	0.0384	24.9059	1.2587	1.1675	1.0829
1999	0.2825	0.0404	14.2872	1.4368	1.3275	1.2266
2000	0.5566	0.0443	7.9499	1.9047	1.7465	1.6014
2001	0.4680	0.0395	8.4396	1.7267	1.5981	1.4791
2002	0.4980	0.0415	8.3298	1.7863	1.6468	1.5182
2003	0.1843	0.0424	23.0085	1.3077	1.2034	1.1075
2004	0.0639	0.0485	75.8448	1.1737	1.0673	0.9705
2005	0.3364	0.0564	16.7524	1.5659	1.4022	1.2555
2006	0.2961	0.0564	19.0457	1.5042	1.3468	1.2058
2007	0.2683	0.0709	26.4264	1.5066	1.3111	1.1410
2008	0.1739	0.0592	34.0118	1.3386	1.1920	1.0616
2009	0.4625	0.0551	11.9019	1.7717	1.5905	1.4278
2010	0.2381	0.0626	26.2871	1.4374	1.2714	1.1246
2011	0.2145	0.0594	27.6685	1.3946	1.2415	1.1051

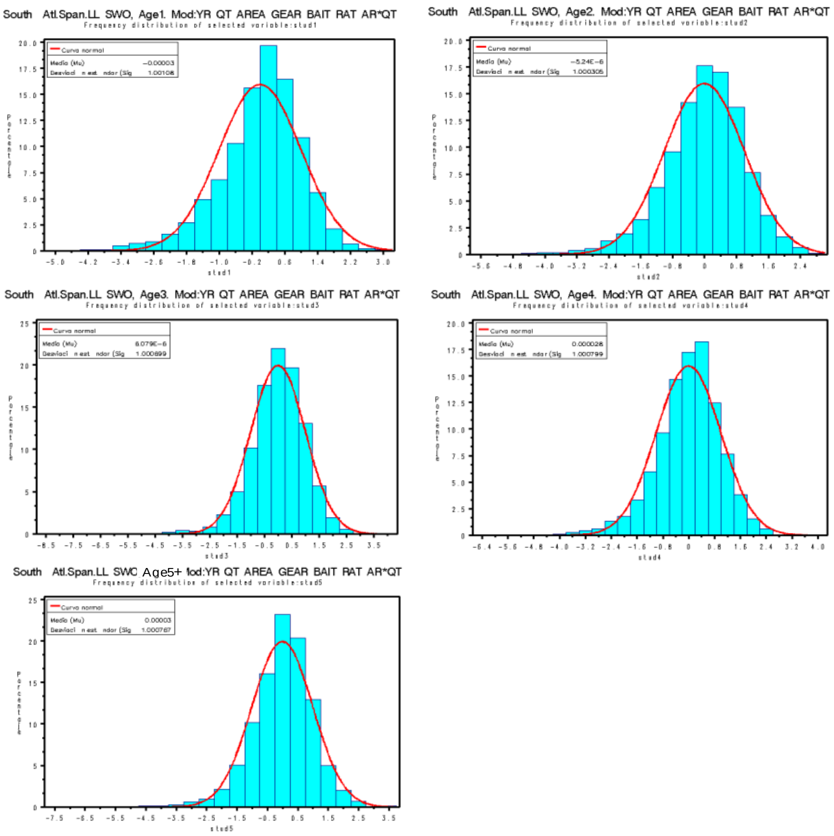

Figure 1. Normal fit and frequency distribution of the standardized residuals obtained as diagnosis of the standardized CPUE in number of swordfish by age, years combined, from the analysis of the South Atlantic stock for the period 1989-2011.

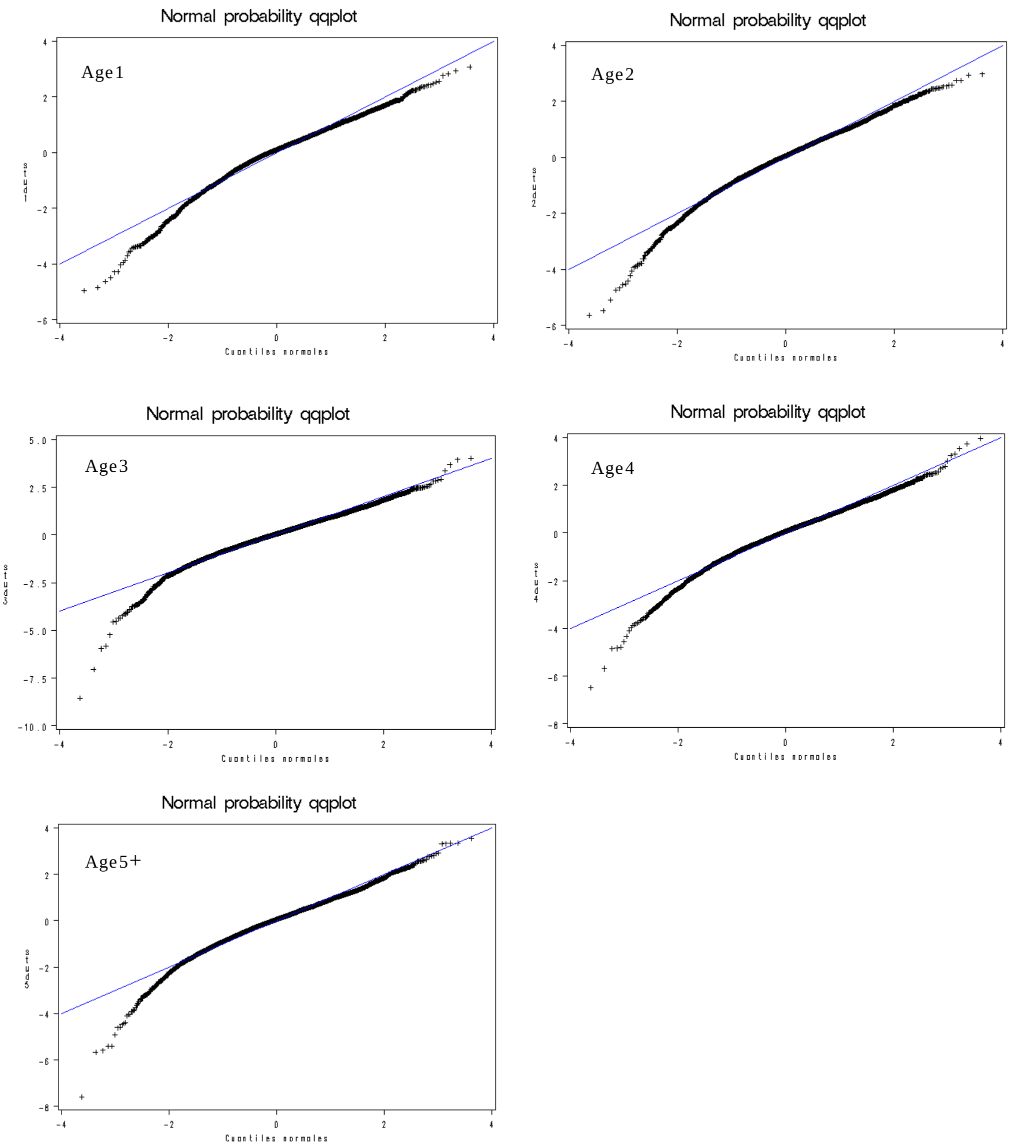

Figure 2. Normal probability qq-plot obtained by age of the GLM base case analysis for standardized CPUE in number of swordfish by age of the South Atlantic stock for the period 1989-2011.

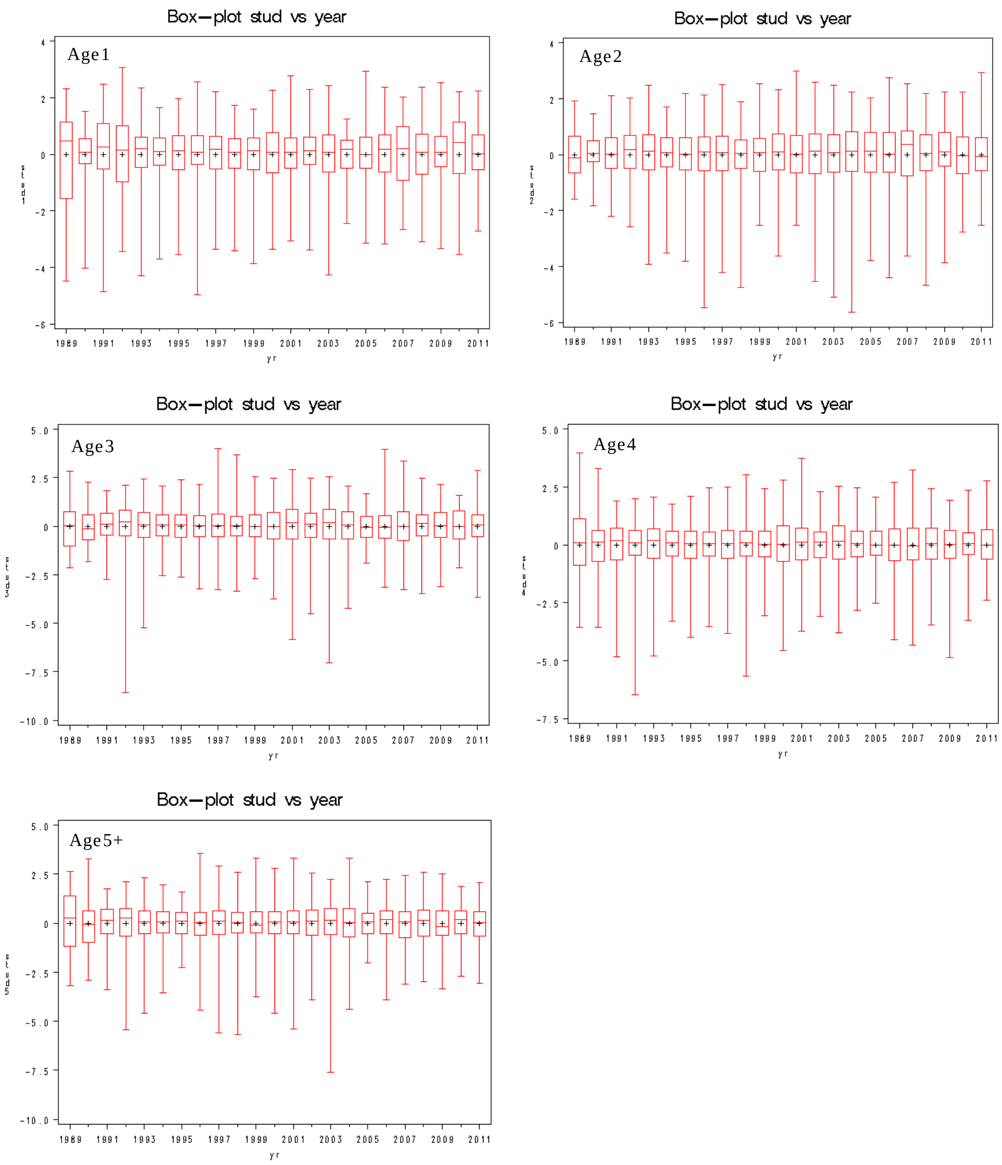

Figure 3. Variability box-plot of the standardized residuals by year obtained by age from the GLM analyses of the standardized CPUE in number by age of swordfish for South Atlantic stock during the period 1989-2011.

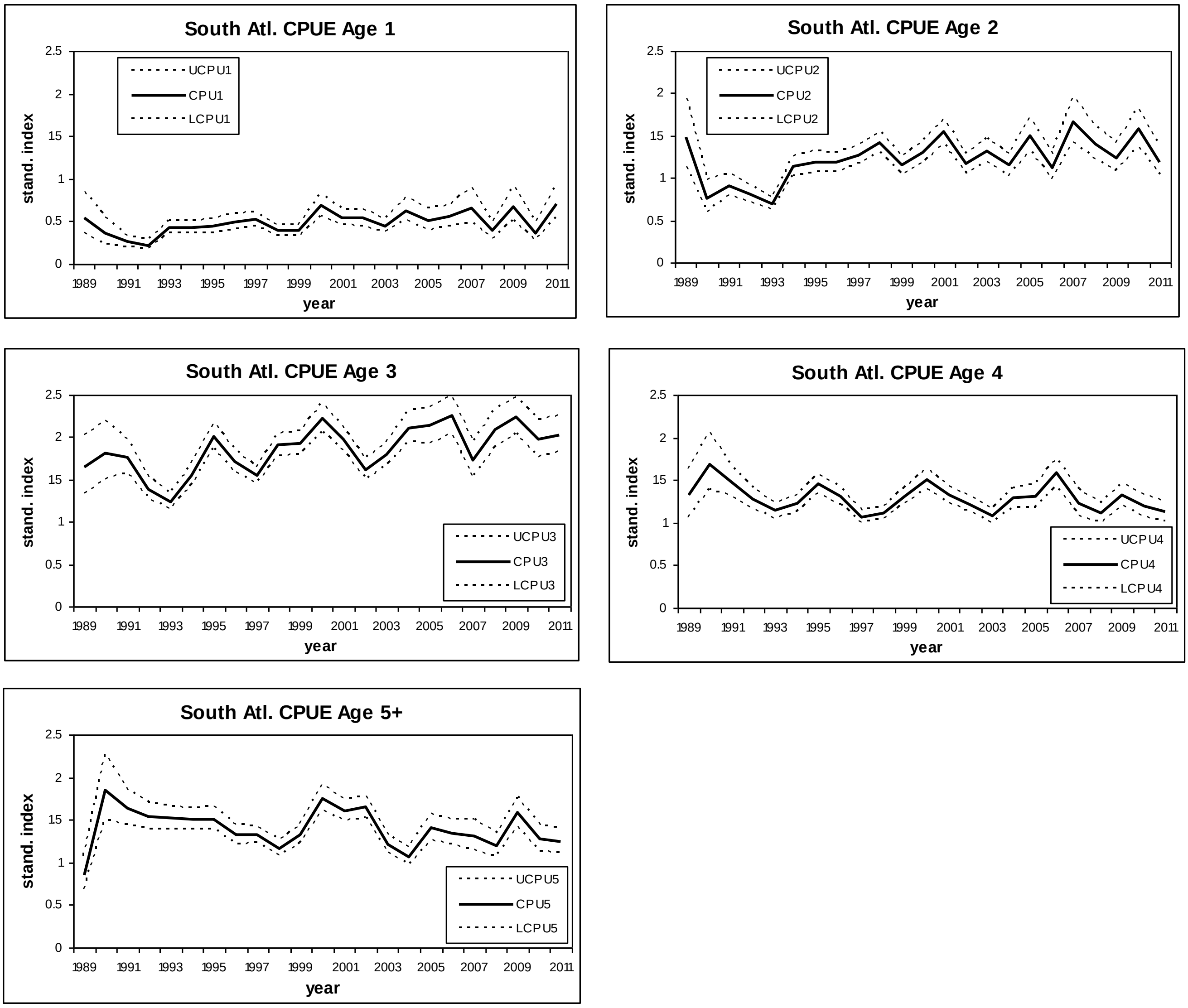

Figure 4. Annual change of the standardized catch rates in number of fish per thousand hooks for ages (1-5+) sex combined, and 95% confidence intervals obtained in the South Atlantic for the period 1989-2011.